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METHOD OF CONVERSION OF MOTION IN POSITIVE-DISPLACEMENT MACHINE AND POSITIVE-DISPLACEMENT MACHINE FOR REALIZATION OF THIS METHOD

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METHOD OF CONVERSION OF MOTION IN POSITIVE-DISPLACEMENT MACHINE AND POSITIVE-DISPLACEMENT MACHINE FOR REALIZATION OF THIS METHOD

[Sposob preobrazovaniya dvizheniya v mashine obbemnogo passhireniya (vyitesneniya) i obbemnaya mashina gorbanya-brodova]

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The invention relates to mechanical engineering, and to construction of motors, /3* compressors, pumps, etc. It can be used in mechanical equipment and in volumetric [displacement] machines producing energy through working means - liquids or gas, for example,

* [The numbers in the right margin indicate pagination of the original text.]

in rotor-piston internal combustion engines with cycles, such as Otto and diesel engines, and in Wankel rotary engines.

All well-known means of converting movement in rotary displacement machines fall into two categories: rotational (differential) and planetary. In the first of these, two components - an engaging [male] and an engaged [female] element with source and reactive profile revolve around immobile axes. In the second, one of these elements moves around the center of the other, stationary element.

For the planetary method of conversion of motion, the number of full cycles of change of the volume of the chamber, limited by the curved-line surface of the rotor and the trochoid surface of the stator [housing] during one rotation of the drive shaft is equal to the number of limbs of the trochoid j=/Z-1/, where Z=2,3,4... - any whole number equal to the number of enveloping internal and external points of overlap of the group of trochoids. The number of cycles of the face of the rotor at which the volume of the working body changes from its minimal to it maximal value equals 2j, and each cycle occurs when the rotation of the center of the planetary element to an angle of $\gamma=\pi Z/(Z-1)$.

Known methods of conversion of motion are used in volumetric machines with one independent degree of freedom of rotational motion with joined, curved-line elements, for example in mechanisms with cycloidal linkage [USSR Certificate of Authorship N. 205567].

These methods are used in trochoidal positive displacement machines in which, during the process of motion of joined male and female elements with internal or external trochoidal [cycloidal] shape, periodic changes in the volume of the displacement chambers occur during different thermodynamic cycles [Beniovich V.S, Apazidi G.D., Boiko A.M, Rotor-piston engines. Moscow: Mashinostroenie, 1968].

In well-known positive displacement machines the interconnected motion of the male and female elements provides synchronization to the mechanism, and if the number of forming curves is greater on the female element than on the male element, then synchronization is provided by self-linkage of the elements themselves, that is, without the use of specialized mechanisms for synchronization.

The closest technical solution to the proposed method is a method of conversion of motion in a trochoidal positive displacement machine is a method that includes cyclically-changing closed volumes between kinematically interconnected elements - a rotor and a housing - female and male elements with cycloidal [trochoidal] interacting [reciprocal] geometric surfaces or during differential motion of both elements [French Patent No. 2719874, 1995].

Well-known methods of conversion of motion in positive displacement machines with joined curved-line elements possess limited technological possibilities which do not allow for an increase in the number of working cycles, realized during one rotation [period of rotation] of the elements of the combustion chamber, as well as increasing the efficiency [KPD] with respect to the absence of reactive force in the base of the stationary body of the machine.

The problem for which this invention provides a solution is broadening the technical and functional possibilities by means of increasing the number of independent degrees of freedom of rotational motion to two and the number of working cycles of change in volume of the working (combustion) chambers in a single rotation of the drive shaft and with a simultaneous decrease of the value of the summary flywheel event and reaction on the bearings of the trochoidal positive displacement machine.

To achieve the above-indicated technical results in a known method of conversion of motion in a positive displacement machine of joined elements of connecting surfaces, with one end of the connecting elements in the shape of a curved surface, and the other in the form of externally or internally connecting surfaces formed from the above-mentioned curved surface, which produces interconnected rotational motion of the joined elements with the possibility of forming working displacement chambers, and by means of the components of a synchronizing connection these elements synchronize the rotation of the joined elements and produce differentially connected rotation of both joined elements around their axes and linkage of the synchronizing connections and two independent rotations where the angular velocity of rotation is determined by the ratio

$$K_{1\omega 1} + K_{2\omega 2} + {}_{\omega 3} = 0$$

where

ω_1, ω_2 are the angular velocity of rotation around the axes of the joined elements,

ω_3 is the angular velocity of rotation of the linkage of the synchronizing connection,

K_1 and K_2 are the static coefficients of the connection

while simultaneously with the rotation of the joined elements around their axes, there also occurs planetary rotation of any of the joined elements around the axis of another element, and the value of the angular velocity of the rotation of the joined elements is determined by the ratio

$$(Z-1)\omega_1 - Z\omega_2 + \omega_0 = 0,$$

where ω_1 is the angular velocity of rotation around it axis of an element with a curved surface, /4

ω_2 is the angular velocity of rotation around its axis of an element whose surface is formed from an internal or external group of the above-mentioned surfaces,

ω_0 is the angular velocity of motion of the axis of an element of planetary rotation,

Z is a whole number with $Z>1$.

In addition, any two of the rotations of two joined elements around their axes and the linkage of the synchronizing connection can themselves be synchronized.

In addition, transmission of motion from one element to another can occur by means of mechanical contact [engagement] of the curved surfaces of the joined elements with formation of a kinematic pair. The closest technical solution to this proposed mechanism is a trochoidal positive displacement machine, consisting of a body with a main axis, in which connecting elements are located which can form working chambers, a synchronizing link between the connecting elements, where one of the elements forms a curved surface, and the other element is an internally or externally engaging group of the above-mentioned curved surfaces.

The working chambers are formed by the engaging elements and two flat walls, the synchronizer is formed from a gear coupling with six external and internal linkages, while the body contains an eccentric [cam] shaft with main journals and a rotor having a number of nodes with arched [curved] sides, positioned in a hinged manner on the cam of the shaft and firmly joined with the gear of the internal linkage which is in constant contact with the external gear of the edge wall [Sukhomlinov R.M. Trochoidal rotary compressors, Objedinenie Visha Shkola Publishers, Gosuniversitet, Kharkov, 1975, pp. 70-71].

A well-known apparatus possesses one independent degree of freedom of rotational motion and limited technical possibilities, with no possibility of increasing the number of working cycles during one revolution [period of rotation] of the elements of the displacement pair, or of increasing efficiency on account of the absence of reactive force at the bases [supports] of the stationary body of the machine. Thus, for example, in a Wankel engine, one full cycle, equal to four indicated working cycles, occurs after three rotations of the cam shaft. In addition, in well-known trochoidal positive displacement machines, at the supports of the stationary body there are significant static reactive and inertial moments that lower the reliability and working life.

The problem solved by this invention is increasing the technical and functional possibilities by means of increasing the number of independent degrees of freedom of rotational motion to two and increasing the range of driving relationships of the mechanisms with curved elements and the number of working cycles of change in volume of the compression chambers during one revolution of the drive shaft with simultaneous decrease of the value of summary flywheel moment and reaction at the bearings of trochoidal positive displacement machines.

To achieve these technical results in a known positive displacement machine containing a body with a main axis, engageable elements able to form working chambers, and a synchronizer having at least one linkage, one of the engageable elements is placed in a hinged manner on the body or on the synchronizer and can rotate around the main axis, and the second engageable element is placed in the synchronizer and can rotate in a planetary manner around the axis of the first element, while one of the engageable elements contains a curved surface and the second element contains either an external or internal flexible group of surfaces formed from the previously mentioned curved surfaces, a synchronizer placed in the body and capable of rotation relative to the main axis, while at least one of the engageable elements and the synchronizer or at least two of the engageable elements are connected to form a kinematic pair, and capable of synchronization of rotation of two engageable elements around their axes or rotation of one of the elements around its axis and rotation of the axis of the second engageable element, executing planetary rotation, around the main axis, in accordance with the ratio

$$K_{1\omega 1} + K_{2\omega 2} + _{\omega 3} = 0$$

where

ω_1, ω_2 are the angular velocity of rotation around the their axes of the above mentioned engageable elements,

ω_3 is the angular velocity of rotation of the axis of the element executing planetary motion,

K_1 and K_2 are the static coefficients of the connection, while any two of the three above mentioned rotations ω_3, ω_1, ω_2 are independent of each other.

In addition, the machine can be equipped with an additional synchronizer connected at lease to any two of the following parts of the positive displacement machine - the synchronizer, the body, or the engageable elements.

In addition, the additional synchronizer can be constructed as a transmission with driving relationship equal plus or minus to one, or as a mechanism of circular reciprocal motion of one of the engageable elements, or as a link gear or as an inverter of the direction of rotation.

In addition the machine can be equipped with an additional kinematic chain, connected with any two of the following parts of the machine - synchronizer, body, engageable elements capable of decreasing by one the number of independent degrees of freedom of the machine.

In addition, the additional kinematic chain can be a planetary geared drive.

In addition, one of the engageable elements consists of cylindrical pins.

In addition it [kinematic chain] can be equipped with a mechanism for transmission of rotation, connected with at least two of the following rotating parts of the machine: engageable elements and additional synchronizer, and having the means to connect to at least two of the rotation elements of an external apparatus.

In addition, it can be equipped with additional engageable elements constructed of [equipped with] the above mentioned curved surface or a limited connecting group of curved surfaces, and with the capability of forming additional working chambers and with capable of rotational and planetary motion, while all engageable elements are positioned either axially together or coaxially in the chambers relative to each other and connected one to the other.

In addition, one of the above mentioned engageable elements can be firmly attached to an additional engageable element, and another engageable element can be firmly attached to a second additional engageable element, while these elements are placed in working chambers coaxially to each other.

In addition, the engageable elements can have the possibility of mechanical contact of their curved surfaces and thus be able to form a kinematic pair.

Figure 1 presents a diagram of a method of conversion of motion in a trochoidal positive displacement machine.

Figure 2 shows a cross section of working chambers of a positive displacement machine with additional male and female elements.

Figure 3 shows the longitudinal dimension of a positive displacement machine constructed with circular forward motion of the male element in the shape of an internal covering.

Figure 4 is the A-A cross section of Figure 3.

Figure 5 shows the longitudinal dimension of a positive displacement machine equipped with circular forward motion of the female element in the shape of a two-node trochoid.

Figure 6 is the B-B cross section of Figure 5.

Figure 7 shows the longitudinal dimension of a positive displacement machine with circular forward motion of the female element in the shape of a two-node trochoid.

Figure 8 is the V-V cross-section of Figure 7.

Figure 9 shows the longitudinal dimension of a positive displacement machine with a synchronizer in the form of a [round] gear with planetary motion of the male element in the shape of an internal covering.

Figure 10 is the G-G cross section of Figure 9.

The proposed method of conversion of motion in a positive displacement machine with conjugated elements of curved form is realized in the following manner. Interconnected rotation with two degrees of freedom of rotational motion of kinematically joined male and female elements and synchronization linkages is realized, and either planetary rotation of one of the joined elements, or differential rotation of both these elements is realized, restricted mutually embracing surfaces on one of the joined elements in the form of a cycloid or trochoid, equidistant above-mentioned surfaces, a curved surface close to the above mentioned, or in the form of fragments of the above mentioned surfaces, and on the second in the form of an externally or internally enveloping group of the above mentioned curved surfaces and forming working [displacement] chambers.

In the presented illustrative material the female and male elements are represented respectively as a rotor and a stator of a positive displacement machine.

As an example of the realization of this method a positive displacement machine is presented, in which the male element consists of an internally enveloping three-cornered rotor 1 [Figure 1], Z=3, the working cavity [housing, chamber] of the female element is a two-cornered epitrochoid stator 5. The rotor 1 executes planetary movement, that is, with angular velocity ω with circumference at the angle θ around the center O with circumference passing through point O_1, while the rotor itself moves with angular velocity $\omega/3$ around its center O_1 in the direction coincident with the movement of its center with circumference, so that its three points A_1, A_2, and A_3 slide along the epitrochoid of the stator, without losing contact with it. In this planetary scheme of motion the epitrochoid stator is stationary.

An additional independent degree of freedom of rotational motion of the conjugated elements is introduced, for example, by activating three rotational movements, two of which are independent, and specifically, during the planetary motion of one of the conjugated elements, additional motion of the second conjugated element around its axis takes place, and during differential rotation of both conjugated elements, additional planetary motion of one of the

conjugated elements around the axis of the second element takes place. The initial phase and direction of each of these rotations, and the values of angular velocities of the rotation of the above mentioned conjugated elements is calculated according to the ratios

$K_1\omega_1+K_2\omega_2+\omega_3=0$ /6

$\omega_1/\omega_0=K$

$\omega_2/\omega_0=[(Z-1)K+1]/Z$

where ω_1 is the angular velocity around its axis of an element whose surface is in the form of the above mentioned curved surfaces, ω_2 is the angular velocity of rotation around its axis of an element whose surface consists of an internally or externally enveloping group of the above mentioned curved surfaces, ω_3 is the angular velocity of rotation of the synchronizing linkage, ω_0 is the angular velocity of motion of the axis of the element executing planetary movement, k_1 and K_2 are the constant coefficients of the links, Z is the number of rotations of the enveloping group of curved surfaces mentioned above, any whole number greater than 1, and K is any real number.

Adding a differential movement to the planetary motion of the rotor, that is forcing the rotor and stator to additionally rotate around their centers O' and O'_1 in one direction, the reverse direction of the planetary motion of the rotor with angular velocity is 2/3/ ω [rotor] and $-\omega$ [stator].

In this case the rotor takes a summary velocity of its own rotation around its center equal to $\omega/3-2/3\omega = -\omega/3$, and the angle of revolution $\psi = -\theta/n$ around O'_1 the center of the rotor O'_1 retains its velocity of movement of circumference $+ \omega$ and angle θ, and the stator takes velocity $-\omega$. This indicates that the peaks A'_1, A'_2 and A'_3 of the three-cornered rotor will in this case describe a hypotrochoid and slide simultaneously along the epitrochoid of the stator, which rotates around its center with an angular velocity of $-\omega$, and the rotor will not lose contact with the stator. The cycle of change of one closed volume between the rotor and the stator decreases to -45° of the angle of revolution of the rotor around its center, or what corresponds to + 135° of the angle of revolution of the center of the rotor - and - 135° of the angle of revolution of the housing around the center of the epitrochoid, that is, the cycle decreases in comparison with the known closest planetary analog with a stationary epitrochoid and three-point rotor by a factor of two [the number of cycles per revolution grew correspondingly by two times], while in comparison with the scheme of differential rotation, [it grew] by four times, which attests to the possibility of intensification of the thermodynamic cycles during such a conversion of motion.

In addition, the center of the rotor and stator rotate in opposite directions, that is counter rotationally, which significantly reduces the summary kinetic and reactive moments of the machine.

The cycle of change of the working volume in the epitrochoid scheme with planetary motion of the rotor [with internal enveloping [surfaces]] with additional rotation of the stator [epitrochoid], in Figure 1 equal to 45°, can be realized with $Z = 3$ and a two-node epitrochoid under various angular initial phases of the center of the rotor and corresponding angular velocities of the elements and their centers, in particular, with the relationship of the angular velocities of rotation of the elements around their centers to the angular velocity of the center of an element executing planetary motion, that is ω_1/ω_0 and ω_2/ω_0.

In particular, with an internally enveloping rotor 1 and epitrochoid stator 5 or with an initial hypotrochoid rotor 1 and an internally enveloping group of trochoid stator 5 the planetary motion of rotor 1 can be described by the ratio $e_{up} + 1/Z\ e_p$, where e_{up} and e_p are the unitary [individual] vectors of angular velocity of the center of rotor 1 and the rotor. To this we add the differential motion of rotation, described by the expression

$K\ e_{TK} + K(Z-1)/Z\ e_p$, receiving K as $e_{TK} + e_{up} + [1+K(Z-1)]/Z\ e_p$.

From this it follows, that with realization of the surface of an element with an internally or externally enveloping group of curved surfaces executing planetary motion, and the surface of an element with a curved surface rotating around its stationary center, the relationships of angular velocity of the element rotating around its stationary center and the angular velocity of rotation [around its center] of an element executing planetary motion to the angular velocity of the movement of the center of the element executing planetary motion is equal respectively to K and $[(Z-1)K+1]/Z$.

Thus, for example, when $Z = 3$, with the planetary motion of the male element of the rotor with internal enveloping [surface?] and additional rotation of the epitrochoid housing and rotor around their centers, we have

$\theta = 45°$, $K = -5$, $K_1 = -5$; $K_2 = -3$; cycle $\gamma = 45°$ of the rotation of the center of the rotor.

$\theta = 135°$, $K = -1$, $K_1 = -$; $K_2 = 1/3$; cycle $\gamma = 45°$ of the rotation of the center of the rotor.

The proposed method of conversion of motion in a mechanism with conjugated curved elements produces differentially connected rotation of these elements and the synchronizing linkage, while the velocity of their rotation is determined in accordance with the ratio

$K_1\omega_1 + K_2\omega_2 + \omega_3 = 0$,

where ω_1 and ω_2 are the angular velocities of rotation of the above mentioned elements, ω_3 is the angular velocity of rotation of the synchronization linkage, K_1 and K_2 are the constant

coefficients of the link, while the values of any two velocities are taken arbitrarily. With such a relationship, indicated by the absence in the mechanism of two degrees of freedom, it works as a differential mechanism.

The following variants of conversion of motion of the mechanism are possible: 1/ without transmission of motion between the female and male elements, in which case their movement is determined by the synchronization linkages without interaction of the conjugated elements themselves; 2/ with transmission of rotation by the interacting conjugated elements, in this case /7
the curved surfaces of the male and female produce mechanical contact, and form a kinematic pair and form the means of resulting transmission of motion between the male and female elements.

In general it is possible to realize a kinematic chain of any number of additional male and female elements mounted in additional synchronization mechanisms with the possibility of rotational and planetary motion, and the basic and additional elements can be located together and side by side.

Figure 2 presents an example of the realization of joining six curved surfaces of four stationary elements. In this variant of a positive displacement machine, an additional curved surface 30 is joined with the external surface of a female - stator 5. Here, if the internal surface of stator 5 is a curved surface, then the additional external surface 30 of the female element - rotor 1 - is also constructed as equidistant curved surfaces, and if the internal surface of stator 5 is constructed as an external enveloping group of curved surfaces, then the external surface of rotor 1 is constructed as an internal enveloping group of curved surfaces. In addition a second female element is introduced - the rotor with surfaces 27 and 31, coaxially placed with the first male element - rotor 1. In this case the internal curved surface 31 of the additional female element is constructed as a joined spring of surface 30 of the first female element - stator 5.

In the presented variant some elements are firmly attached to each other. Thus, one of the elements - stator 5 - is firmly attached to the additional element with curved surface 30, with the equidistant surface of the element - stator 5, or with the surface which in turn envelopes the group of curved surfaces; another element with surface 31 is firmly attached with another additional element, constructed with surface 27, while all elements with surfaces 30, 31, 27, and 29 are coaxially placed within each other.

The method of conversion of motion in a positive displacement machine according to Figure 2 is realized in the same way as in Figure 1 but takes into account the simultaneous interaction of three pairs of conjugated surfaces.

The positive displacement machine in which the proposed method is realized is a stationary housing containing female and male conjugated elements constructed respectively as elements with conjugated surfaces in the form of a cycloid or trochoid, or equidistant above mentioned surfaces, or curved surfaces close to the former, or as fragments of these surfaces, while one of the conjugated elements is restricted by an above mentioned curved surface, and another is restricted by an external or internal enveloping group of these curved surfaces, and contains its own housing and synchronization mechanism - a synchronizer, mechanically connected conjugated elements and a stationary housing. In this mechanism with two degrees of freedom the conjugated elements are constructed with the possibility of simultaneous interconnected planetary motion of one of these elements around the axis of the other element and rotation of another of these elements, hinged to the housing, around its axis.

The positive displacement machine is equipped with an additional joined synchronization mechanism; the conjugated elements are the main synchronization mechanism and the housing.

Figures 3 and 4 schematically present a two-stage trochoidal positive displacement machine, including a female element stator 5 with a trochoidal internal surface and flat end walls [not shown in the drawing], stationary housing 6, a synchronizing link - crankshaft 7 with main journals hinged in the stationary housing 6, female element in the form of rotor 1 with a curved external surface hinged to the joint journal of crankshaft 7, the synchronizing element constructed as parallel crankshafts 22, joint journals hinged to the stationary housing 6, and joint journals hinged to rotor 1, while the radii of crankshaft 7 and crankshafts 22 are randomly chosen, and stator 5 is hinged to the stationary housing 6 and can rotate around it own axis and is mechanically joined with the additional synchronization mechanism. Crankshaft 7 is connected with stator 5 and with the joint journals of the parallel crankshafts 22 through a mechanism for transmission of rotation, for example, a reduction gear or a multiplier with gears 23, 24, 25, and 26. Rotor 1 is constructed as a three-cornered internal enveloping component, and stator 5 as a two-node trochoid.

Work in the mechanism proceeds according to the schematic in Figure 1, but with forward motion of rotor 1. During rotation of the crankshaft 7 the kinematic bond of the gears 23, 24, 25, and 26 enables rotation of stator 5 with angular velocity two times less and in the opposite direction to crankshaft 7. Thanks to parallel crankshafts 22, rotor 1 executes circular forward motion. At $Z = 3$ the three-cornered rotor 1 with internal enveloping and two-node trochoid stator 5 [complete] an angular cycle of change of the closed volumes equal to $\gamma = 90°$ according to the angle of revolution of stator 5, that is, a full cycle, including four engine cycles, of work of the positive displacement machine takes place during one revolution of stator 5. /8

Figure 5 presents a variant of a two-stage positive displacement machine, which works in an analogous manner to the machine in Figure 3, but in this machine rotor 1 is constructed with an external surface in the form of a two-node trochoid, and stator 5 is constructed with an internal three-node externally-enveloping surface [Z=3]. In this machine rotor 1 is also installed in crankshaft 22, enabling its circular forward motion around axis O, and stator 5 is hinged to the housing and is capable of rotation. However in this variant rotor 1 and stator 5 form a self-synchronizing kinematic pair since the number of forming nodes [three] on the female element - stator 5 - is greater than the number on the male element - rotor 1, which has two nodes. In this case a synchronizer is not needed.

The positive displacement machine works in the following manner.

During rotation of crankshaft 7 [Figure 5] rotor 1 executes circular forward motion in a synchronizing element - the system of parallel crankshafts 22. During motion of rotor 1 self-engagement of the rotor takes place with the internal surface of stator 5, and as a result stator 5 engages rotor 1 and rotates in the same direction as crankshaft 7. The ratio of angular velocities of rotation of crankshaft 7 and stator 5 equals 3/1/.

In the closed volumes, which change during rotation of crankshaft 7, between rotor 1, stator 5 and the flat end walls [not shown] thermodynamic cycles of positive displacement machines can occur. In particular, the four-stroke cycle of an internal combustion engine is realized in the mechanism in Figure 5 during a single rotation of stator 5, which enables gas distribution in the closed volumes of the machine presented in Figure 5 using a valve [not shown] on the stationary housing.

Figures 7 and 8 present another variant of a trochoid machine with two degrees of freedom, which includes a two-node trochoid stator 5 with a center O and flat end walls [not shown], a three-node rotor 1 with curved surface placed in the cavity of stator 5, a stationary housing 6, and a synchronization mechanism for the motion of rotor 1 and stator 5. The synchronizer is realized as parallel crankshafts 22, whose journals are hinged to the stationary housing 6, and the hinged journals are hinged stator 5, while the stator is capable of circular forward motion whose center is coincident with axis O - O of the shaft of rotor 1, hinged in the stationary housing 6 and capable of rotation around it axis O - O and kinematically connects with the synchronizing element in the form of crankshaft 22 through a mechanism for transmission of rotation, for example, a reduction gear or a multiplier with round gears 23, 24.

The work of the positive displacement machine in Figure 7 proceeds according to the schematic in Figure 1, but using the circular forward motion of stator 5. In this machine during rotation of rotor 1 the round gears 23 and 24 enable rotation of the main collar of the unitary crankshafts 22, firmly joined with round gears 24 to the eccentricity "e," with angular velocity,

for example, at Z=3, three times greater than the velocity of the shaft of rotor 1. Since the trochoid housing 5 is hinged, in suspension, in the offset collars of crankshafts 22, then during rotation of crankshafts 22 stator 5 executes a circular forward motion, which corresponds to the schematic of Figure 1 in the case of rotational motion of rotor 1 and circular forward motion of stator 5.

In the variants of the machine shown in Figures 3, 5, and 7 the choice of the value of eccentricity "e" does not affect the value of the diameters of the synchronizing round gears 23, 24, 25, and 26, which lets us use these schematics for the work of machines such as internal combustion engines with ignition of compressed fuel, where the value e is usually small.

Figures 9 and 10 present a trochoid machine with two degrees of freedom, including trochoid stator 5 and flat end walls [not shown], a three-node rotor 1 with a curved external surface, a stationary housing 6, a synchronizing link in the form of crankshaft 7, whose main journals are hinged to the stationary housing 6 and capable of rotation, and pairs of round gears 3 and 4, in continuous contact, one of which is connected to rotor 1 and the other to stator 5, and additional synchronization mechanism - a synchronizer consisting of round gears 2 and 8, the latter of which is geared internally, connected with the stationary housing 6, and the other is externally geared and installed on rotor 1. The movable trochoid stator 5, three-node rotor 1 on the cam, two round gears 2 and 3 on rotor 1, round gear 4 on the trochoid stator 5 and the immobile round gear 8 form a counter-rotational trochoid positive displacement machine.

The work of a trochoid positive displacement machine proceeds in the following manner. During rotation of the eccentric [cam] crankshaft 7 the round gear 2 of rotor 1 embraces the internal surface of the immobile round gear 8 and forces rotor 1 to execute planetary motion. The round gear 3 rotates the round gear 4 of the trochoid stator 5, which counter-rotates with respect to crankshaft 7. The change of the working volumes of the changer between rotor 1, stator 5 and the flat end walls of stator 5 occur two times more frequently than in the prototype, and the peaks of the rotor describe a hypotrochoid and simultaneously slide along the epitrochoid.

The given case uses a synchronizer in the form of a pair of round gears 2 and 8. It is possible to construct a synchronizer in the form of a link gear with a rotation link or an inverter of the direction of rotation [not shown].

Rotor 1 and stator 5 in other variants of a positive displacement machine can be constructed as elements of a lantern gear, a wheel with cylindrical pins and a round gear with /9
cycloid enveloping [surface].

In the general case, two rotation elements of a trochoid machine, one with counter-rotation, can be connected by means of driving gears with rotating elements of external

equipment or mechanisms, with which the transmission of rotational moments can be realized either from a trochoid machine to external equipment or in the reverse direction. Such a link can be realized, for example, with a counter-rotary turbine, a compressor or a counter-rotary electric machine.

A trochoid machine can be equipped with a valve capable of sliding along a face or cylindrical surface of one of the conjugated elements [not shown].

The advantage of the invention consists in decreasing the angular extent of thermodynamic cycles, decreasing the flywheel resultant moment and the reaction on the bearings of the machine, improvement of volumetric specific indicators during realization of two-stage counter-rotary positive displacement machines and other variants and of two-stage positive displacement machines in accordance with this invention.

Claims

1. A method of conversion of motion in a positive displacement machine, having conjugated elements, restricted mutually-embracing surfaces, constructed on one of the conjugated elements as a curved surface, and on the other as an external or internal enveloping group of surfaces, and constructed from the above-mentioned curved surface, including the fact that they execute mutually-joined rotational motion of the male and female conjugated elements and are capable of forming working displacement chambers and through linkages of synchronizing connections can synchronize the rotation of the male and female conjugated elements, distinguished by the fact that they produce differentially connected motion of the two above mentioned conjugated elements around their axes and the synchronizing linkage, two rotations of the above mentioned are independent of one another, while the angular velocity of rotation is determined by the ratio

$$K_1\omega_1 + K_2\omega_2 + \omega_3 = 0$$

where ω_1 and ω_2 are the angular velocities around their axes of the above mentioned conjugated elements;

ω_3 is the angular velocity of rotation of the synchronizing linkage;

K_1 and K_2 are the constant coefficients of the link;

while simultaneously with the rotation of the conjugated elements around their axes there is additional planetary rotation of any of the conjugated elements around the axis of another

element, and the value of angular velocities of the rotation of the conjugated elements is taken from the ratio

$$(Z-1)\omega_l - Z\omega_0 + \omega_2 = 0,$$

where ω_l is the angular velocity of rotation around its own axis of an element whose surface is constructed as a curved surface;

ω_2 is the angular velocity of rotation around its own axis of an element whose surface is constructed as an internally or externally enveloping group of surfaces from the above mentioned curved surfaces;

w_0 is the angular velocity of the motion of the axis of an element executing planetary rotation;

A is a whole number, $Z > 1$.

2. A method as in Example 1, distinguished by the fact that, any two rotations of the rotations of two conjugated elements around their axes and the synchronizing linkage are synchronized.

3. A method as in Example 1 or 2, distinguished by the fact that transmission of motion from one element to another is accomplished through mechanical contact of the curved surfaces of the male and female conjugated elements with resultant formation of a kinematic pair.

4. A positive displacement machine containing a housing with a main axis, male and female conjugated elements, constructed with the capability of forming working chambers, and a synchronizer having at least one linkage, one of the conjugated elements hinged to the housing or the synchronizer and capable of rotation around the main axis, and the other conjugated element located in the synchronizer and capable of planetary rotation around the axis of the first element, while one of the conjugated elements is constructed from curved surface, and the second element is constructed in the form of an externally or internally enveloping group of surfaces formed from the above mentioned curved surfaces, distinguished by the fact that the synchronizer is placed in the housing and is capable of rotation relative to the main axis, while at least one of the conjugated elements and the synchronizer or at least two of the conjugated elements are interconnected and form a kinematic chain capable of synchronizing the rotation of two conjugated elements around their axes or the rotation of one of the conjugated elements around its axis and the rotation of the axis of the second conjugated element executing planetary rotation around the main axis in accordance with the ratio

$K_1\omega_1 + K_2\omega_2 + \omega_0 = 0,$

where ω_1 and ω_2 are the angular velocities around their axes of the above mentioned conjugated elements;

ω_0 is the angular velocity of rotation of the axis of the element executing planetary motion;

K1 and K2 are the constant coefficients of the link, while two of the three above mentioned rotations ω_0, ω_1, and ω_2, are independent of each other.

5. A machine as in Example 4, distinguished by the fact that it is equipped with an additional synchronizer, connected at least with any two of the following parts of the positive displacement machine - synchronizer, housing, conjugated elements.

6. A machine as in Example 5, distinguished by the fact that an additional synchronizer is provided in the form of a transmission with a gear ratio equal plus or minus to one, or a mechanism of circular forward motion of one of the conjugated elements, or a link gear, or an inverter of the direction of rotation.

7. A machine as in Example 4, 5, or 6, distinguished by the fact that it is equipped with an additional kinematic chain, connected with any two of the following parts of the machine - synchronizer, the housing, conjugated elements capable of decreasing by one the number of independent degrees of freedom of the machine.

8. A machine as in Example 7, distinguished by the fact that an additional kinematic chain is realized as a planetary toothed transmission.

9. A machine as in Examples 4, 5, 6, 7, or 8, distinguished by the fact that one of the conjugated elements is constructed with cylindrical pins.

10. A machine as in Examples 4, 5, 6, 7, 8, or 9, distinguished by the fact that it is equipped with components for transmission of rotation, connected with at least with two of the following rotating parts of the machine: conjugated elements and additional synchronizer and having the means to connect at least two rotation elements of the internal components.

11. A machine as in Examples 4, 5, 6, 7, 8, 9, or 10, distinguished by the fact that it is equipped with additional male and female conjugated elements, constructed from the above mentioned curved surfaces or restricted enveloping groups of the above mentioned curved surfaces, capable of forming additional working [displacement chambers] and capable of rotational and planetary motion, which all conjugated elements are placed either with their axes together or coaxially in the chambers relative to each other and connected one to the other.

12. A machine as in Example 11, distinguished by the fact that one of the above mentioned conjugated elements is firmly connected with another additional conjugated element, another conjugated element is firmly connected with a second additional conjugated element, while these elements are placed in working chambers coaxially relative to each other.

13. A machine as in Examples 4, 5, 6, 7, 8, 9, 10, 11, or 12, distinguished by the fact, that the male and female conjugated elements are capable of mechanical contact of their curved surfaces and can thus form kinematic pairs.

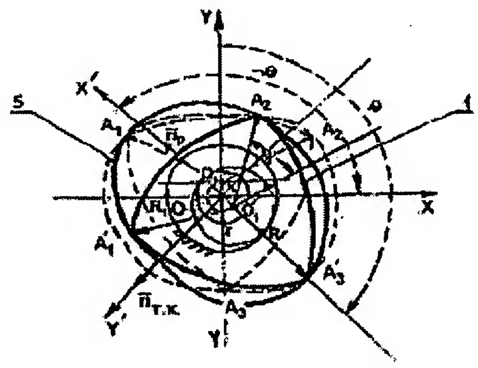

Figure 1

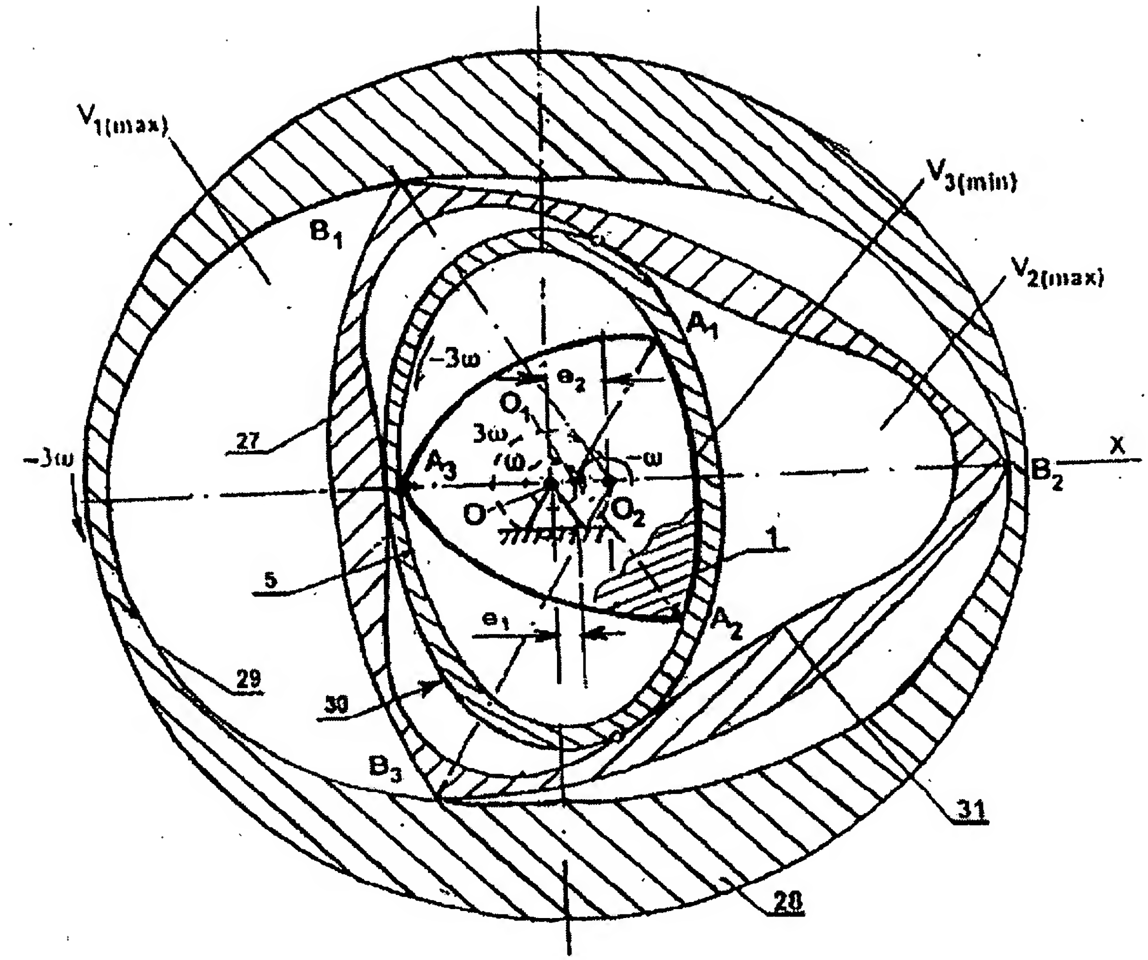
V1(max)
V3(min)
V2(max)
B1
A1
-3ω
e2
O1
3ω
ω
-ω
27
-3ω
A3
X
B2
O
O2
1
5
A2
e1
29
30
B3
31
28

Figure 2

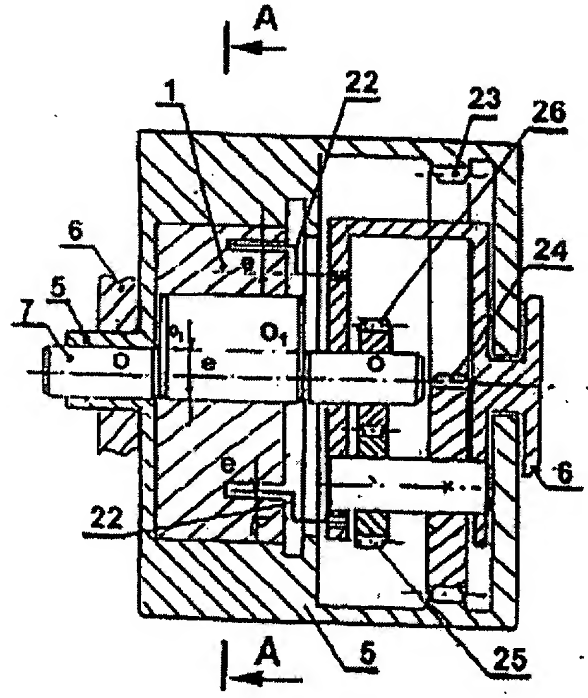

Figure 3

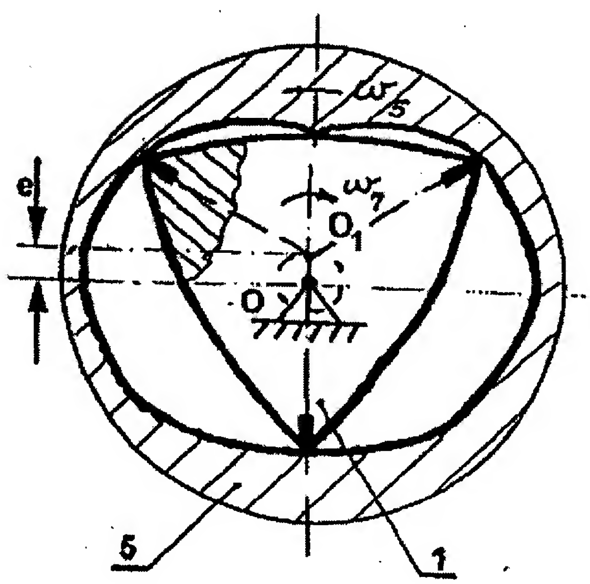

Figure 4

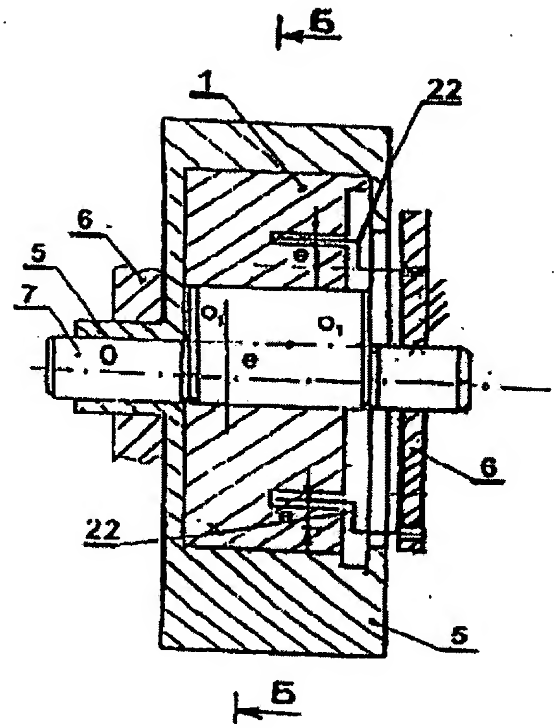

Figure 5

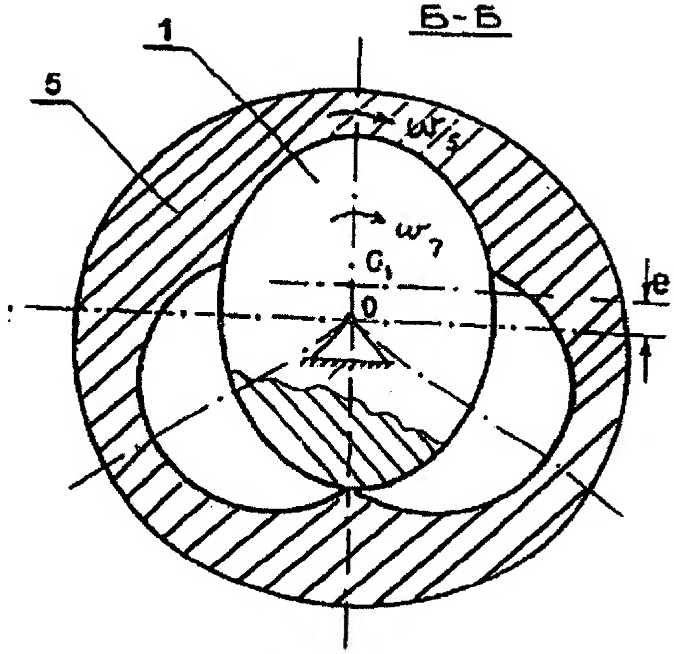

Figure 6

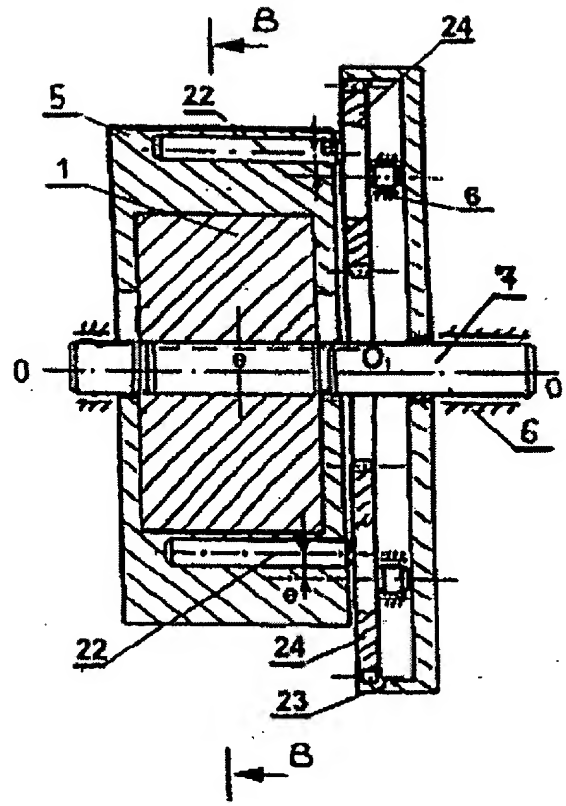

Figure 7

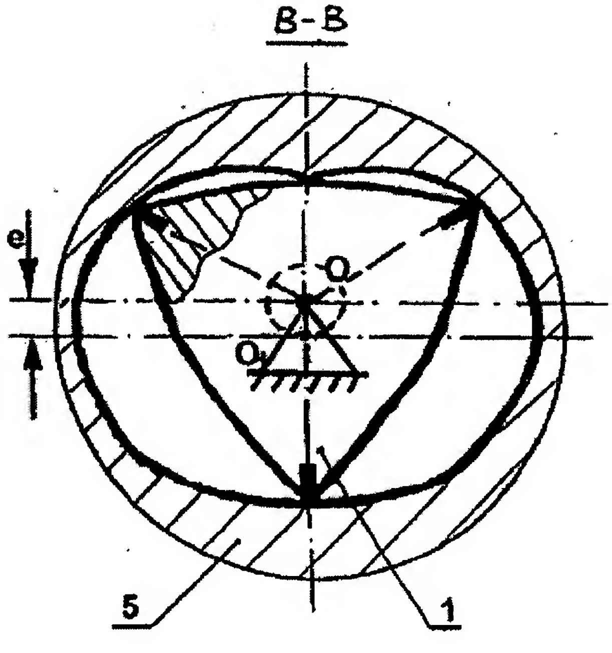

Figure 8

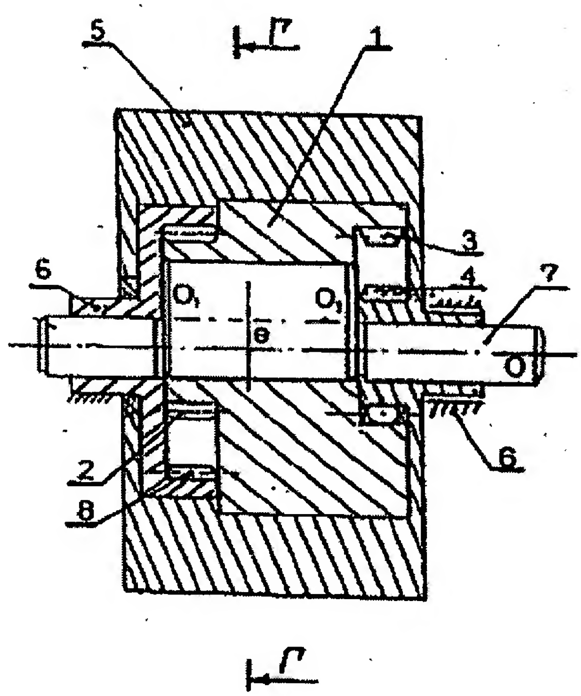

Figure 9

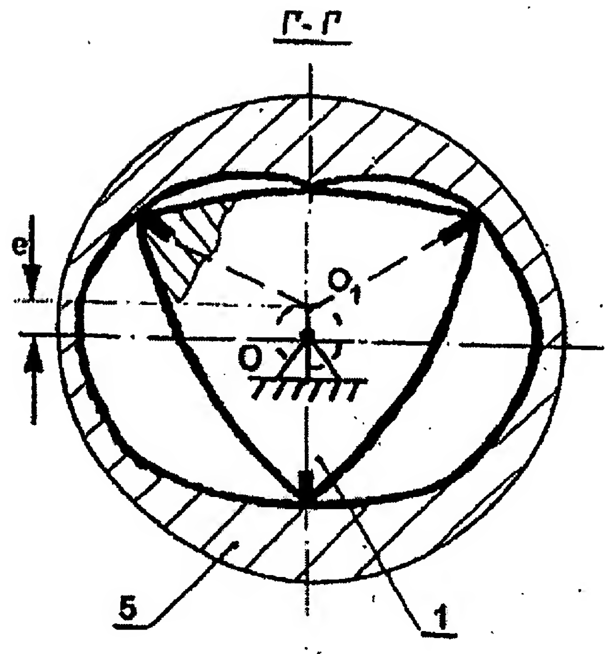

Figure 10